

CHAPTER 3

UTILITY SYSTEMS

Chapter Objective: Upon completion of this chapter, you will have a working knowledge of the operating principles and components of bleed-air utility systems.

The utility systems of an aircraft provide an additional measure of flight safety, pilot comfort and convenience, and contribute to the overall mission capability of the aircraft.

BLEED-AIR UTILITY SYSTEMS

Learning Objective: Recognize the operating principles and components for systems within the bleed-air utility system.

Many aircraft have utility systems that rely on a bleed-air system to function. The P-3C deicing system and the A-6E rain removal system are examples of such systems and are discussed in this chapter. This material will increase your proficiency in troubleshooting and maintaining these and similar systems.

DEICE SYSTEMS

An anti-icing system is designed to prevent ice from forming on the aircraft. A deicing system is designed to remove ice after it has formed. An aircraft deice system removes ice from propellers and the leading edges of wings and stabilizers. These systems may use electrical heaters, hot air, or a combination of both to remove the ice formation. As an AME, you are primarily concerned with hot air as a method to remove the formation of ice on wings and stabilizers. The P-3C wing deice system is used as an example in this chapter to describe a hot-air system.

Description and Components

The P-3C wing deice system uses hot compressed bleed air from the engines. The air is

ducted from the 14th stage of each engine compressor, as shown in figure 3-1. The bleed air is maintained at a fixed percentage of engine airflow for all altitudes and flight speeds.

The hot bleed air is directed and regulated to the leading edge ejector manifold through shutoff valves, modulating valves, thermostats, skin temperature sensors, and overheat warning sensors.

SHUTOFF VALVES.— The wing deice system contains several shutoff valves. The fuselage bleed-air shutoff valves, installed in the cross-ship manifold on the right and left wings, isolate the wings from the fuselage duct section. In addition, they may be used to isolate one wing duct from the other wing duct. Each valve is individually controlled by a guarded toggle switch mounted on the bleed-air section of the ice control protection panel.

A bleed-air shutoff valve is also installed in each engine nacelle. These shutoff valves are physically identical. They are of the butterfly-type, and they are actuated by an electric motor.

An indicator, located on top of the valve housing, shows the position of the valve—open or closed. This indicator enables you to visually check the operation of the valve while it is still installed in the deice system.

MODULATING VALVES.— The P-3C deicing system has three modulating valves installed in each wing. These valves are thermostatically controlled and pneumatically operated. They maintain the constant engine compressor bleed-air temperature required for the wing leading edge. When deicing is not required, the valves operate as shutoff valves.

The modulating valves, shown in figure 3-2, have pilot solenoid valves that are electrically

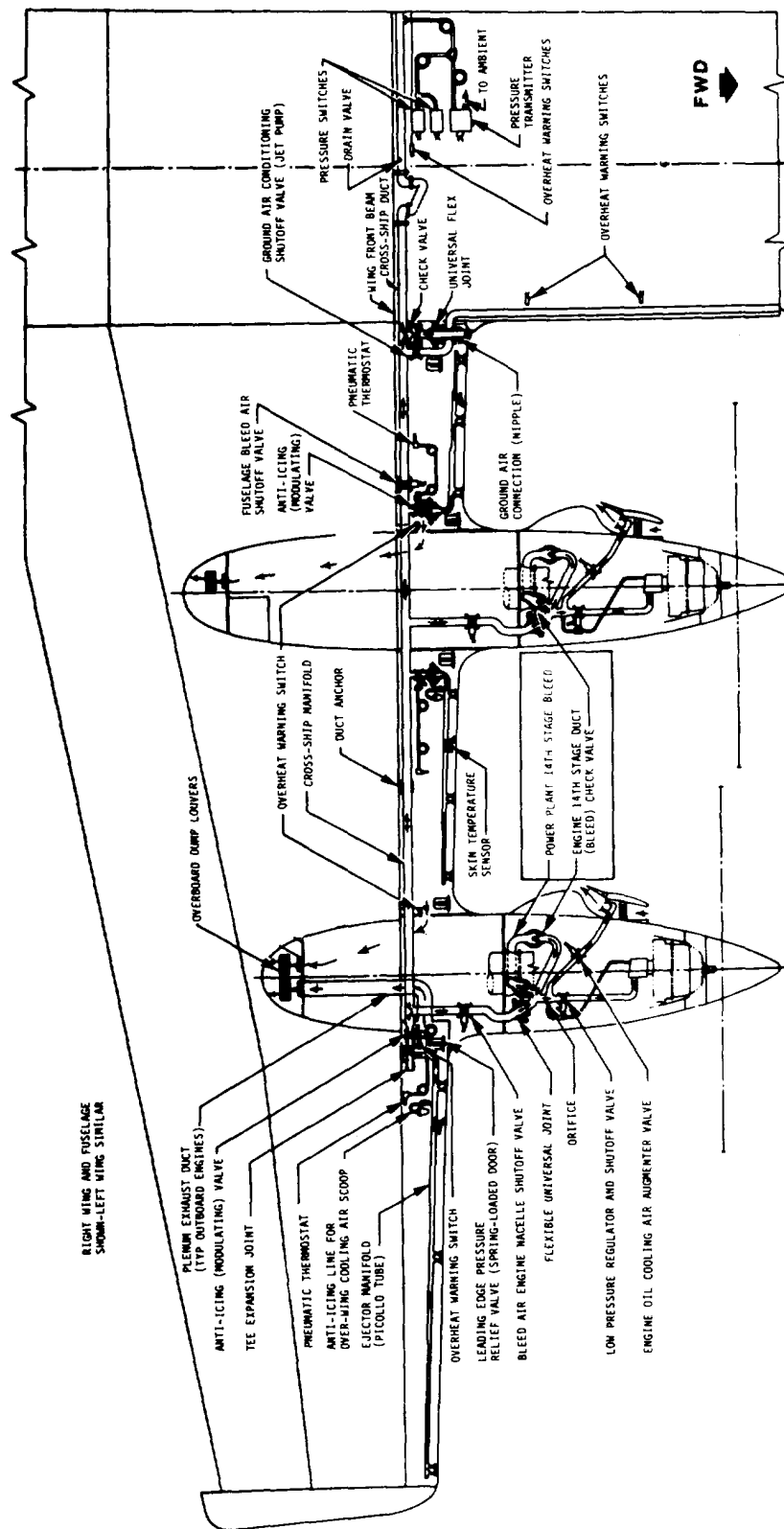


Figure 3-1.—P-3C wing deicing system schematic.

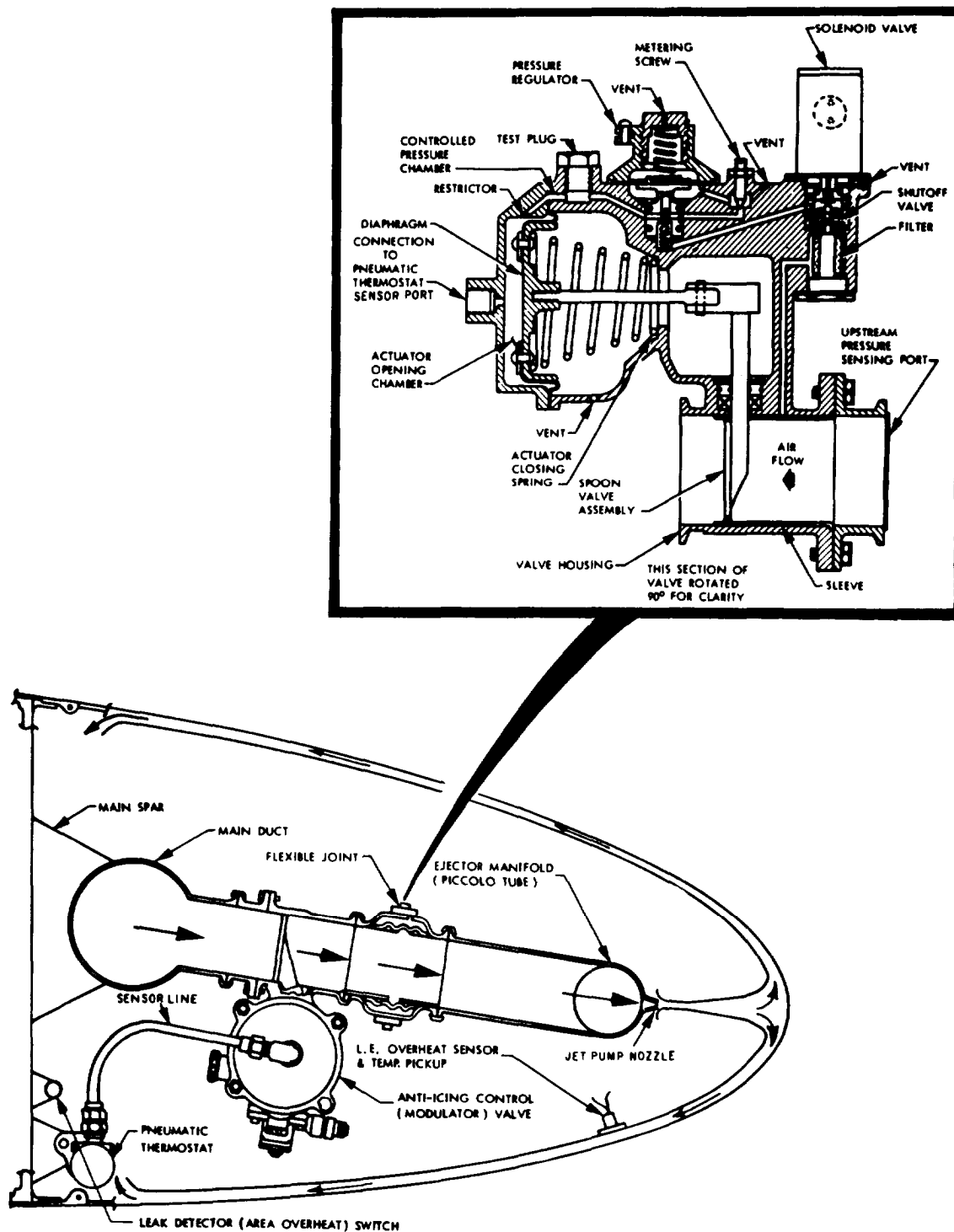


Figure 3-2.-Anti-icing modulating valve.

controlled by three switches on the bleed-air section of the ice protection panel. When the solenoid is energized, it admits filtered, regulated, bleed-air pressure to one side of a diaphragm chamber in the valve. The other side of the diaphragm chamber is spring-loaded to the closed position. Movement of the diaphragm operates a main line butterfly valve.

When the valve opens, hot air is admitted to the leading edge distribution system. The hot air goes through the modulator valve to the ejector manifold, out the jet nozzles, and into the wing leading edge plenum area. The bleed air is then directed across a pneumatic thermostat. Increased temperature across the thermostat actuates the sensor and opens a bleed passage from the diaphragm chamber. This reduces the pressure on the diaphragm and allows a spring to close the main valve.

THERMOSTATS.— The wing leading edge pneumatic thermostat is installed adjacent to each modulating valve. (See fig. 3-2.) The thermostat controls air pressure on the modulating valve diaphragm, and thereby controls the valve opening.

The unit is composed of a probe and a valve assembly. (See fig. 3-3.) The probe is a core made of layers of high- and low-expansion material that is locked to a sliding piston. In addition, the piston contains an override spring and ball-type metering valve.

Airflow from the leading edge flows over the core and causes the materials to expand or

contract. As temperature rises, the core pulls the piston and metering ball from the seated position. This allows pressure from the modulating valve diaphragm to vent. Increasing temperature causes more air to be bled from the diaphragm chamber. Because of spring action, the modulating valve moves toward the closed position. This restricts flow through the modulator valve and drops the skin temperature.

LEADING EDGE TEMPERATURE AND OVERHEAT CIRCUIT.— To monitor the overheat warning system, six skin temperature sensors (one in the inboard section, one in the center section, and one in the outboard section of each wing) form a part of an amplifier circuit. When the wing leading edge skin temperature rises in excess of 230°F at any one or more sensors, the airfoil temperature control unit amplifier completes a caution light circuit, thus illuminating the leading edge caution hot light.

Also, there are three ducting overheat thermal switches installed in each wing and three installed in the fuselage adjacent to the bleed-air duct. These switches form a part of a loop that is connected to a signal light control assembly. When any one of the thermal leak detector switches closes, its respective caution light illuminates. Also, when the test switch is placed in the TEST position, both lights illuminate through their respective loop circuit.

The ducting overheat switches are single-pole, single-throw, explosiveproof, thermally actuated electrical switches with an integral temperature

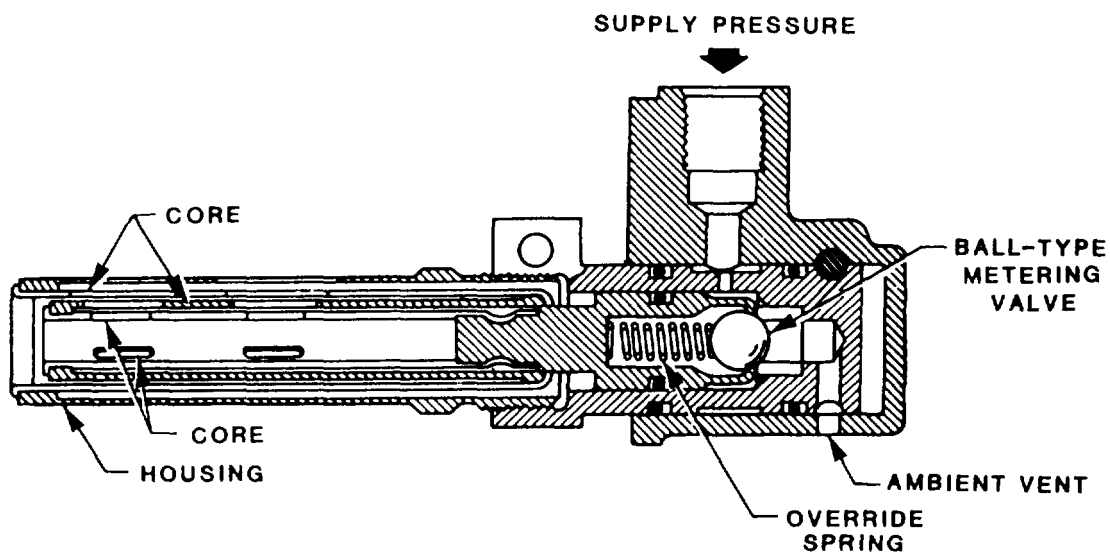


Figure 3-3.-Wing leading edge thermostat.

sensing element. The switches sense still air temperature. The outboard leading edge overheat warning switches open at approximately 205°F and close at approximately 220°F. The other wing and fuselage overheat warning switches open at approximately 175°F and close at approximately 190°F.

High temperature within the leading edge is generally caused by bleed-air leakage or malfunctioning modulator valves. You can detect the portion of the leading edge that has the overtemperature by placing the rotary selector switch, located on the ice control protection panel, to the different sensor positions: INBD, CTR, and OUTBD. (See fig. 3-4.) The temperature at the selected sensor is then read at the indicator adjacent to the rotary switch. An excessive temperature reading on the indicator denotes a malfunction within the area being tested.

Operation

Figure 3-4, the ice control protection panel, shows a basic diagram of the wing deice system. Each engine is labeled by an engine number. Directly below each engine block (in the diagram) is an OPEN light that illuminates when the bleed-air valve is open 2 degrees or more. The cross-ship manifold from the bleed-air valves goes to

each modulating valve and the fuselage shutoff valves. The fuselage bleed-air shutoff valves are normally in the CLOSE position during normal deicing operation. The bleed-air pressure gauge reads cross-ship manifold pressure when one or both switches are opened.

A ground air-conditioning switch is located directly under the bleed-air manifold pressure gauge. Located above the switch is an annunciator light, which indicates VALVE OPEN when the ground air-conditioning valve is open. Either one or both fuselage bleed-air shutoff valves must be open to direct air to the ground air-conditioning unit.

A leak test switch is mounted on the upper right-hand side of the panel. This switch is used to determine if the leakage of the system is acceptable.

Three modulating valve control switches are located on the left side of the wing and empennage ice panel. The outboard switch controls the outboard modulating valve on the left and right wing, the center switch controls the two center modulating valves, and the inboard switch controls the two inboard modulating valves.

During normal operation of the deicing system, all four engine bleed-air valves are open to supply bleed air to the cross-ship manifold, and both fuselage bleed-air shutoff valves are closed.

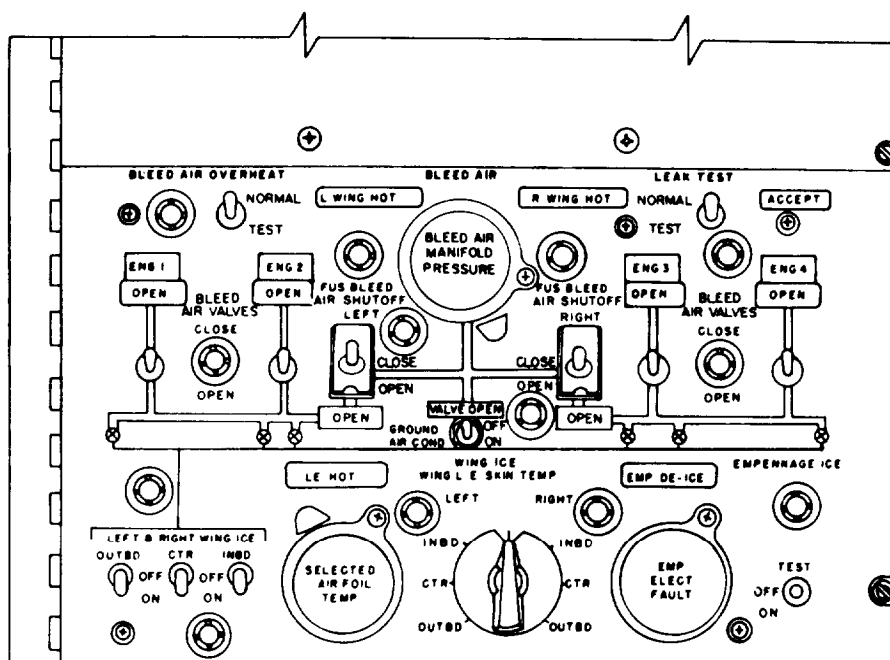


Figure 3-4. Ice control protection panel.

The modulating valves maintain a controlled flow of bleed air to the leading edge distribution system, and they are controlled by pneumatic thermostats. The complete system is monitored for hot spots by heat-sensing switches.

Before flight, the deicing manifold system may be tested for leakage. This leak test is performed by pressurizing the system: OPEN the No. 4 engine bleed-air valve; the Nos. 1, 2, and 3 engine bleed-air valves remain CLOSED, and both fuselage shutoff valves are in the OPEN position. When the bleed-air pressure on the bleed-air manifold reads 70 psi, the No. 4 engine bleed-air valve is closed and the leak test switch is actuated. As the bleed-air pressure drops, the time-delay relay will illuminate the ACCEPT light after an 8-second delay if the system is tight. The light will go out when the test switch is released.

Maintenance

The involvement of the AME2 and AMEC in the maintenance of the deicing system normally consists of troubleshooting. To troubleshoot intelligently, you must be familiar with the system.

In addition, you must know the function of each component in the system and have a mental picture of the location of each component in relation to other components in the system. This can be achieved by studying the schematic diagrams of the system.

As an aid, the aircraft manufacturer furnishes troubleshooting charts, which give recommended procedures to follow during troubleshooting. Figure 3-5 shows a deicing system overheat warning troubleshooting chart. This chart lists the most probable cause first and then branches to the next most probable cause. By following the recommended charts and procedures, you can save many valuable maintenance hours.

RAIN REMOVAL SYSTEM

The rain removal system shown in figure 3-6 controls windshield icing and removes rain by directing a flow of heated air over the windshield. This heated air serves two purposes. First, the air breaks the rain drops into small particles, which are then blown away. Secondly, the air heats the windshield to prevent the moisture from freezing

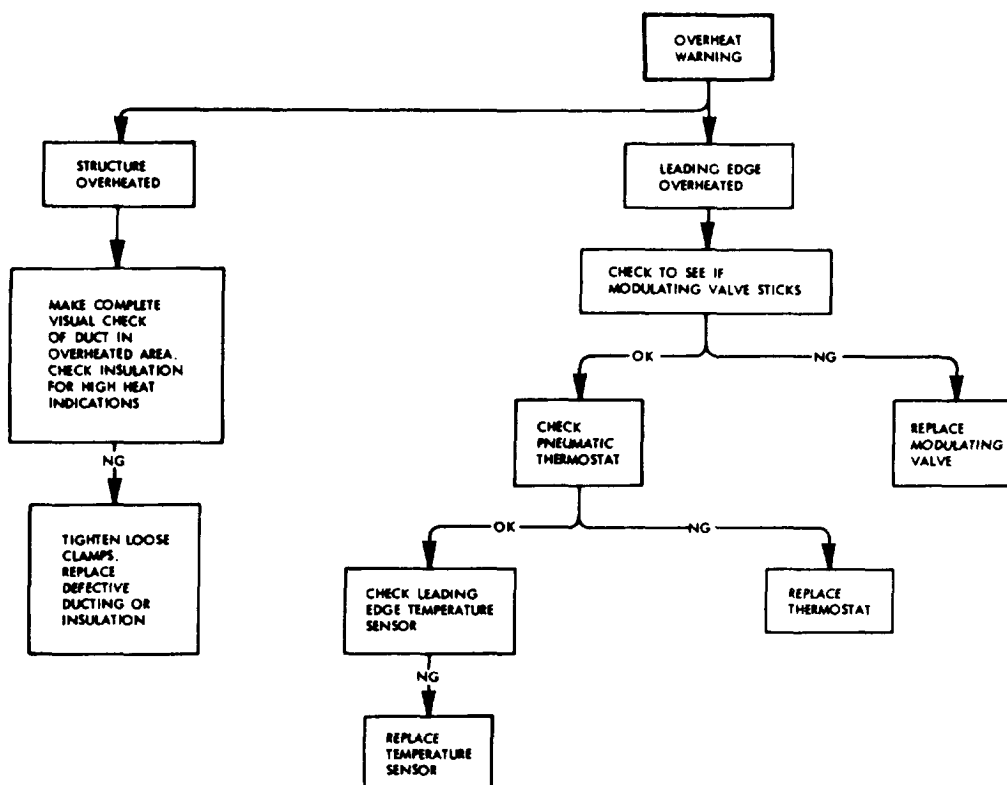


Figure 3-5.-Deicing troubleshooting chart.

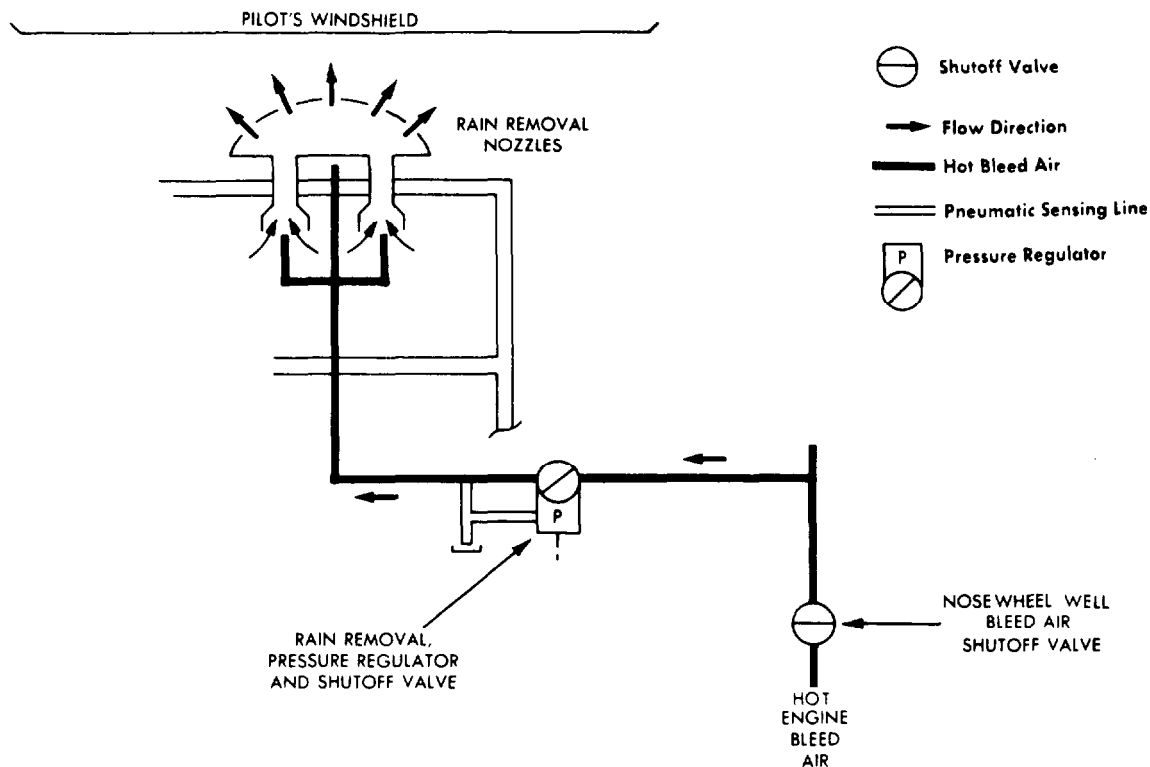


Figure 3-6.-Rain removal system.

on it. The A-6E rain removal system (for those aircraft with airframes change number 268 incorporated) is discussed in the following paragraphs.

Description and Components

The rain removal system is controlled by the windshield switch located on the air-conditioning control panel in the cockpit. (See fig. 3-7.) The

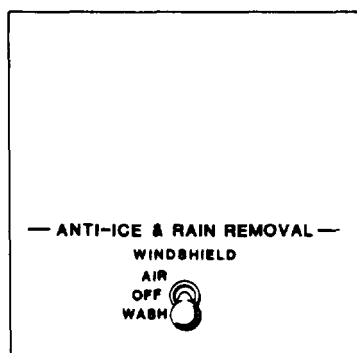


Figure 3-7.-Air-conditioning panel.

system uses hot bleed air from the 12th stage compressor section of each engine. The nosewheel well bleed-air shutoff valve controls the flow of hot bleed air to the rain removal system.

Then the rain-removal, pressure-regulator shutoff valve controls the airflow from the rain-removal system to the windshield. When this valve is open, it allows hot bleed air to flow to the rain-removal nozzle assembly. The nozzle distributes the air through a series of diffuser outlets to form a wide stream of hot air over the windshield. The temperature of the air is lowered by a mixing ejector at the inlet of the rain-removal nozzle assembly. The ejector uses hot bleed air as its primary air, and it draws secondary air from the nose radome compartment to cool the rain-removal air.

In the next several paragraphs, we will discuss the major components of the rain removal system. You should know the location and functions of these components to aid you in troubleshooting and maintaining the system.

NOSEWHEEL WELL BLEED-AIR SHUT-OFF VALVE.— The nosewheel well bleed-air shutoff valve is a butterfly-type that is

electrically actuated and operated. The valve is installed in the hot bleed-air duct in the starboard engine compartment. The valve is controlled by the nosewheel well bleed-air switch on the fuel management panel. When the switch is set to the OFF position, the valve is closed by 115-volt ac power from the bleed-air circuit breaker. When the switch is set to the AUTO position, power is routed to the nosewheel well bleed-air relay. When the windshield switch on the air-conditioning panel is moved to the AIR position, or when left main landing gear weight-on-wheels switch is closed, the relay is activated and the valve opens. If electric power is lost, the valve will remain in the last selected position. The valve has a position indicator that can be viewed with the starboard engine-bay door open.

RAIN-REMOVAL PRESSURE-REGULATOR SHUTOFF VALVE.— The rain-removal pressure-regulator shutoff valve is a pneumatically

operated, solenoid-controlled, 2-inch valve installed in the hot bleed-air duct to the rain-removal nozzle assembly. (See fig. 3-8.) Operation of the valve is controlled by the windshield switch on the air-conditioning control panel. Placing the switch to the AIR position energizes the solenoid of the valve. When the inlet pressure to the valve is between 15 and 50 psi, the valve is fully opened. When it is between 100 and 250 psi, the valve regulates the outlet pressure to the rain-removal nozzle at 75 ± 3.5 psi. By placing the windshield switch to OFF, it de-energizes the solenoid. This causes the valve to close and shuts off the flow of bleed air to the rain-removal nozzle.

In the closed position, air from the upstream side of the valve passes through the control air passages to chamber A and leaks past the pilot valve stem to chamber B. With equal pressure on both sides of the large diaphragm, the pressure on the small diaphragm and the spring force on

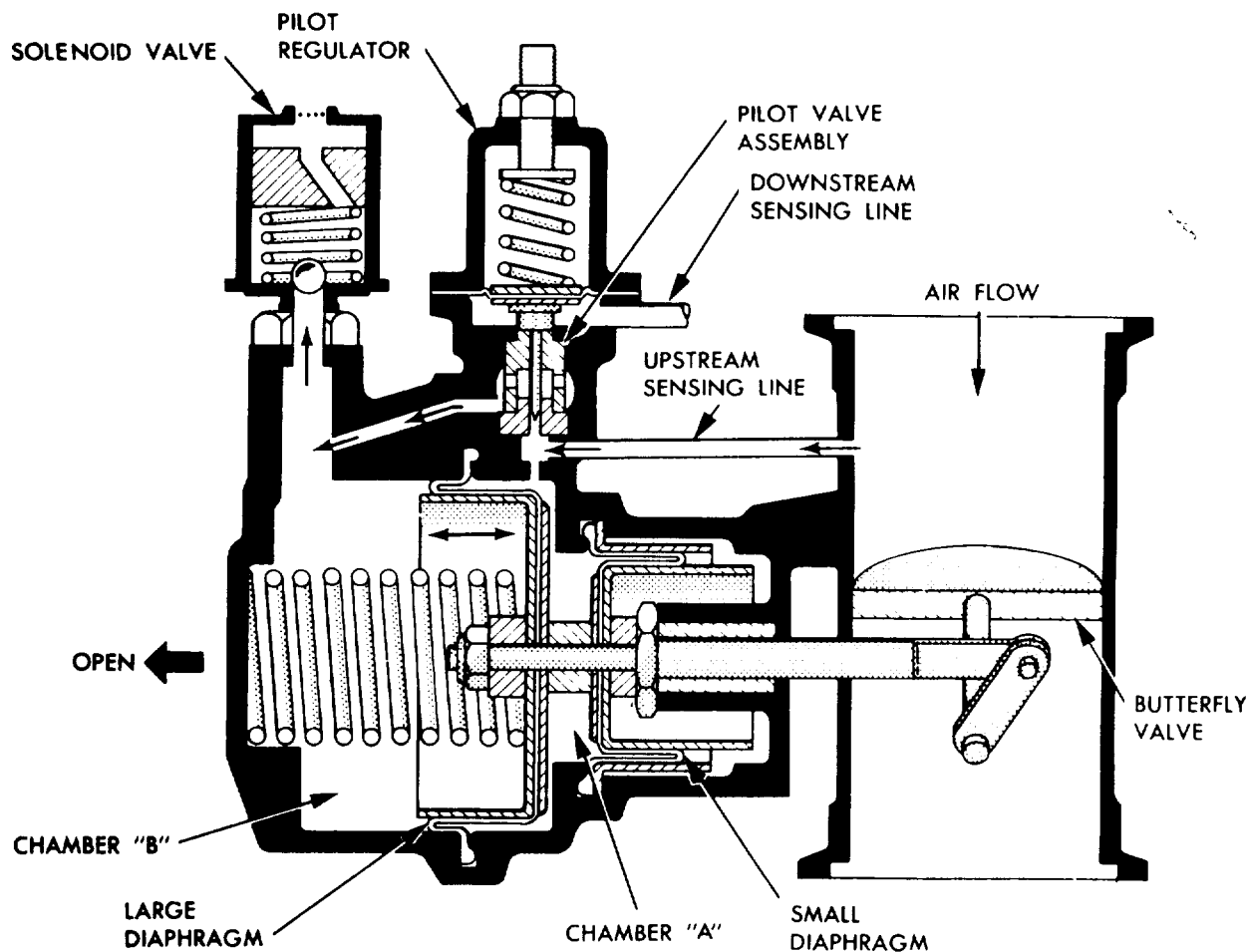


Figure 3-8. Rain-removal Pressure-regulator shutoff valve.

top of the large diaphragm combine to hold the valve closed.

When the solenoid is energized, air supplied to chamber B bleeds off through the solenoid and the butterfly valve opens. As the butterfly valve opens, air pressure from the downstream side of the valve is applied to the bottom of the pilot regulator diaphragm. This unseats the regulator valve stem and permits upstream air to flow to chamber B. As the downstream pressure varies, a varying amount of air is metered by the pilot regulator valve to chamber B. The metering positions the diaphragm and the butterfly valve to maintain the proper downstream pressure. If the downstream pressure increases to a value in excess of the regulator setting, the pilot valve opens. When this occurs, the solenoid valve is not capable of bleeding off the increased airflow in chamber B. Therefore, chamber B pressure increases, and the butterfly valve moves toward the closed position until regulation pressure is reached.

RAIN-REMOVAL NOZZLE ASSEMBLY.— The rain-removal nozzle assembly consists of two ejectors, a plenum chamber, and 26 nozzles. The bleed-air duct has two nozzles aligned with and located beneath each ejector tube. The ejectors mix cool air from the nose radome compartment with the hot bleed air. The mixture is distributed by the plenum to the nozzles, which results in a wide stream of air across the windshield. The plenum chamber provides an approximately equal pressure at each nozzle. The rain-removal nozzle assembly is beneath the left windshield,

WINDSHIELD SWITCH.— The windshield switch is a single-pole, three-position switch mounted on the air-conditioning control panel in the cockpit. The three positions are OFF, AIR, and WASH. This switch controls the operation of the windshield-washing shutoff valve and rain-removal pressure-regulator shutoff valve. The switch is spring-loaded to the OFF position. The AIR and WASH positions are momentary contacts. If the switch is placed in the WASH position, it directs streams of washing fluid against the base of the windshield. If it is placed to the AIR position, it directs a wide stream of hot air across the glass.

NOSEWHEEL WELL BLEED-AIR SWITCH.— The nosewheel well bleed-air switch is a single-pole, two-position switch mounted on the fuel management panel in the cockpit. The

two positions are OFF and AUTO. This switch controls the operation of the nosewheel well bleed-air shutoff valve. Placing the switch in the OFF position closes the nosewheel well bleed-air shutoff valve. When the switch is set to AUTO position, the nosewheel well bleed-air shutoff valve will open when the rain-removal system is energized or when the left main landing gear weight-on-wheels switch is actuated.

NOSEWHEEL WELL BLEED-AIR RELAY.— The nosewheel well bleed-air relay is a double-pole, double-throw, relay mounted in aft bay relay box No. 3. Its operation is controlled by the windshield switch on the air-conditioning panel or by the left main landing gear weight-on-wheels switch. When energized, the relay completes a 115-volt ac circuit to open the nosewheel well bleed-air shutoff valve. When de-energized, the relay completes a 115-volt ac circuit to close the nosewheel well bleed-air shutoff valve.

LEFT MAIN LANDING GEAR WEIGHT-ON-WHEELS SWITCH.— The left main landing gear weight-on-wheels switch is a double-pole, double-throw switch mounted on the lower torque arm of the left gear shock strut. The switch is closed when the shock strut piston is extended. When the shock strut piston is compressed, the plunger of the switch is fully extended. When the switch plunger is extended, a 28-volt dc circuit is completed to energize the nosewheel well bleed-air relay.

WINDSHIELD RAIN-REMOVAL WARNING RELAY.— The windshield rain-removal warning relay is a double-pole, double-throw, sealed relay mounted in the cockpit center console below the wing fold panel. Its operation is controlled by the windshield switch on the air-conditioning panel. When the windshield switch is in the AIR position, 28 volts of dc power is directed from the air-conditioning circuit breaker to energize the relay and illuminate the windshield air caution light. The relay is de-energized when the windshield switch is set to OFF. At this time, the windshield air caution light will go out.

WINDSHIELD AIR CAUTION LIGHT.— The windshield air caution light is located on the caution light panel in the cockpit. It illuminates to indicate that the windshield switch is in the AIR position. The operation of the light is controlled by the windshield rain-removal warning relay.

System Operation

The rain-removal system is activated by placing the windshield switch in the AIR position. With the switch in the AIR position, a 28-volt dc circuit is completed from the air-conditioning circuit breaker, through the windshield switch, to the solenoid of the rain-removal pressure-regulator shutoff valve, to the nosewheel well bleed-air relay, and to the windshield rain-removal warning relay. When the nosewheel well bleed-air relay is energized, the 115-volt ac circuit from the bleed-air circuit breaker, through the AUTO position of the nosewheel well bleed-air switch, is completed to the open windings of the nosewheel well bleed-air shutoff valve. With the circuit completed, the windshield air caution light will illuminate. When you move the windshield

switch to the OFF position, the windshield air caution light will go out. The nosewheel well bleed-air shutoff valve directs the 115-volt ac power to the close windings of the motor. The weight-on-wheels switch will energize the nosewheel well bleed-air relay.

When the rain-removal pressure-regulator shutoff valve solenoid is energized, the valve opens and allows pressure-regulated (75 ± 3.5 psi) hot bleed air to flow to the ejectors of the rain-removal nozzles. To lower the temperature of the hot bleed air, the ejectors draw cool air from the nose radome compartment. The cool air and hot bleed air mix in the plenum of the nozzle assembly. The air passes through the plenum to 26 nozzles, which direct the hot air in a wide stream across the windshield.